Distribution pattern of rare plants along riparian zone in Shennongjia Area

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Abstract: Due to the importance of riparian zone in maintaining and protecting regional biodiversity, increasingly more ecologists paid their attentions to riparian zone and had been aware of the important effects of riparian zone in basic study and practical management. In this study, 42 sampling belts (10 m×100 m) parallel to the bank of Xiangxi River at different elevations in Shennongjia Area were selected to investigate the riparian vegetation and rare plants. 14 species of rare plants were found distributing in riparian zone, accounting for 42.4% of the total rare plant species in Shennongjia Area. The main distribution range of the 14 rare plant species was the evergreen and deciduous mixed broadleaved forest at elevation of 1 200-1 800 m, where, species diversity of plant community was the maximum at the moderate elevation. The analysis of TWINSPAN divided the 14 rare species into 3 groups against the elevation, namely low elevation species group, moderate elevation species group, and high elevation species group. The analysis of DCA ordination showed similar results to that of TWINSPAN. In the paper, the authors discussed the reasons forming the distribution pattern of rare plant species, and pointed out that the important function of riparian zone on rare plant species protection.

Keywords: Xiangxi River; Rare plant; Riparian zone; Distribution pattern; Biodiversity
CLC number: S718.54 **Document code:** A **Article ID**: 1007-662X(2002)01-0025-03

Introduction

Riparian zone is a kind of landscape representation of aquatic-terrestrial ecotone where there exist obvious gradients of environmental factors, ecological process, and plant communities (Gregory *et al.* 1991). Riparian zone also plays an important role in maintaining and protecting regional biodiversity (Naiman *et al.* 1993; Deng *et al.* 2001). In the past 20 years, increasingly more ecologists paid their attentions to riparian zone and knew more effects of riparian zone based on theoretic studies and management practice (Deng *et al.* 2001). Studying biodiversity protection from the viewpoint of riparian zone is an important aspect of relative studies, and most of studies are focused on vascular plants (Decamps *et al.* 1992; Naiman *et al.* 1993). At present, people have been known the important function of riparian zone in rare plants protection, but no relative study has been carried out.

Shennongjia Mountain lies in the transitional terrain from north subtropical zone to warm temperate zone. During the Fourth Glacial Epoch, this area was avoided from the direct attack of glacier due to aegis of Qinling Mountain and Daba Mountain, and became the refuge for many ancient plants. But now, forest vegetation and species resources in this area are under the pressure of increasing population and economic activities. So, protecting rare plants became an important issue. The protection should be carried out under the scale of ecosystem and landscape (Jiang *et al.* 1998), so, it is necessary to survey the rare plants resources and their distribution pattern at first, and the protection strategies should be discussed consequently.

Study sites and methods

Study area

This study was carried out in Xiangxi River Watershed in Shennongjia Area. Xiangxi River originates from Heng River in the south Shennongjia Mountain, passes through Muyu County and Honghua County in Shennongjia forest region, and inpours into the Yangtze River. It is 94 km long, and the area of the watershed is 3 900 km^2. The frost-free season is 265 d in low elevation area and 115 d in high elevation area. From the source to Yangtze River, Xiangxi River passes through three vegetation zones such as coniferous forest, coniferous and broadleaved mixed forest, and evergreen and deciduous mixed broadleaved forest (Zheng *et al.* 1998). The coniferous forest is distributed at elevation of 2 300-3 100 m, and *Abies fargesii* is the main tree species. In the coniferous and broadleaved mixed forest, which is distributed at elevation of 1 600-2 300 m, the main coniferous species include *Pinus armandii*, *Tsuga*

Foundation item: This project was supported by National Natural Science Foundation of China (NSFC39970123), and Changbai Mountain Open Research Station, Chinese Acedamy of Science.
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Received date: 2001-12-06
Responsible editor: Chai Ruihai

chinensis, and *Pinus henryi*, and the main broadleaved species are *Quercus aliena* var. *acuteserrata*, *Fagus engleriana*, *Betula albo-sinensis*, and *Populus davidiana*. The evergreen and deciduous mixed broadleaved forest is distributed at elevation below 1 600 m, consisting of evergreen species, which mainly include *Cyclobalanopsis glauca*, *Castanopsis fargesii*, *Machilus ichangensis*, *Cyclobanopsis myrsinaefolia*, *Cinnamomum wilsonii*, *Lithocarpus cleistocarpus*, and *Daphniphyllum glaucescens*, and deciduous species, which include *Juglans cathayensis*, *Castanea sequinii*, *Quercus aliena*, *Platycarya strobilacea*, and *Carpinus ssp.*. This forest was destroyed in different degrees because of human activities.

Methods

Forty-two sampling belts (10 m×100 m) parallel to the riverbank at different elevation were selected to investigate the riparian vegetation and rare plants. Basic parameters such as altitude, slope degree, and vegetation coverage of each unit were recorded. For herbs and shrubs, species, abundance, coverage, and average height were investigated, and for trees, species, diameter, and height were investigated.

Software STATISTICA was used to analyze the relationship between elevation gradients and richness of rare plants. TWINSPAN and DCA were used to study the distribution pattern and ordination of rare plants.

Results and analysis

Species component of rare plants

Fourteen species of rare plants were recorded in the riparian zone of Xiangxi River Watershed (Table 1), accounted for 42.4% of the total rare plant species in Shennongjia Area. Among the 14 rare plant species, there were one herbal species and 13 tree species (account for 92.9% of the total), and among the tree species, there were one coniferous and 12 deciduous species.

Vertical distribution of rare plants

The 14 rare plant species were distributed mainly in the evergreen and deciduous mixed broadleaved forest at elevation of 1200-1800 m (Fig. 1). Two species, *Euptelea pleiospermum* and *Pteroceltis tatarinowii*, were distributed downward to elevation of 300-500m. Very few species were distributed upward to the coniferous and broadleaved mixed forest at elevation of 2 200 m.

Rare plant species richness in each elevation interval of 200m from elevation of 200 m to 2 200 m was calculated (Fig. 2). The peak value of rare plant species richness was found in the elevation of 1 200-1 600 m, and in the higher and lower elevation sections, the rare plant species richness decreased correspondingly. By using nonlinear equations to imitate the relationship between rare plant species richness and elevation, the relationship was significant and could be expressed in parabola equation:

$$SR = 0.3636E^2 + 4.5333E - 5.7333 \quad (1)$$

(R^2=0.624, P<0.05)

where SR was rare plant species richness, and E was elevation.

Table 1. Rare plant species in riparian zone of Xiangxi River Watershed

Species name	Code	Protect class	Habitat
Davidia involucrata	Dain	I	Tree
Tetracentron sinense	Tesi	II	Tree
Cercidiphyllum japonicum	Ceja	II	Tree
Liriodendron chinense	Lich	II	Tree
Emmenopterys henryi	Emhe	II	Tree
Sinowilsonia henryi	Sihe	II	Tree
Dipteronia sinensis	Disi	III	Tree
Euptelea pleiospermum	Eupl	III	Tree
Tapiscia sinensis	Tasi	III	Tree
Pterostyrax psilophyllus	Ptps	III	Tree
Corylus chinensis	Coch	III	Tree
Pteroceltis tatarinowii	Ptta	III	Tree
Amentotaxus argotaenia	Amar	III	Tree
Dysosma versipellis	Dyve	III	Herb

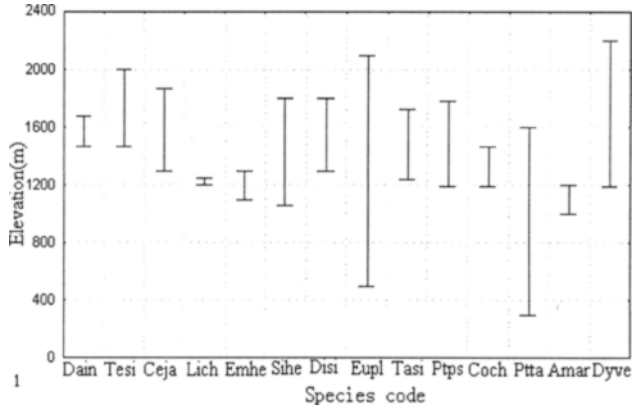

Fig. 1 Elevation distribution range of 14 rare plant species along riparian zone

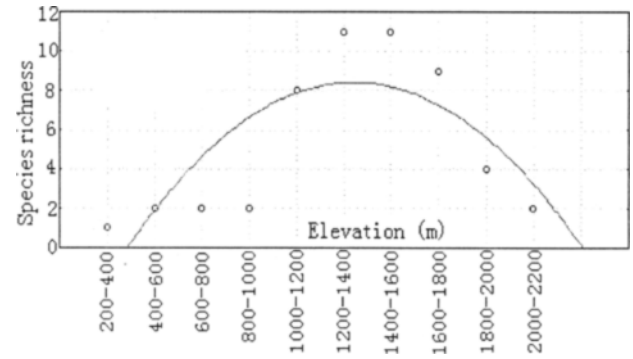

Fig. 2 Relationship between rare plant species richness and elevation

Spatial distribution pattern of rare plants

Based on the relationship between rare plant species richness and elevation, TWINSPAN analysis and DCA ordination of rare plant species along riparian zone were done according to dualistic data of rare plant species in elevation section. The result of TWINSPAN showed that the 14 rare plant species could be divided into three groups namely low elevation species group, which mainly contained *Euptelea pleiospermum* (Eupl) and *Pteroceltis tatarinowii* (Ptta), moderate elevation species group, which contained *Liriodendron chinense* (Lich), *Emmenopterys henryi* (Emhe), *Sinowilsonia henryi* (Sihe), *Pterostyrax psilophyllus* (Ptps), *Corylus chinensis* (Coch), and *Amentotaxus argotaenia* (Amar), and high elevation species group, which contained *Davidia involucrate* (Dain), *Tetracentron sinense* (Tesi), *Cercidiphyllum japonicum* (Ceja), *Dipteronia sinensis* (Disi), *Tapiscia sinensis* (Tasi), and *Dysosma versipellis* (Dyve). Figure 3 shows the DCA ordination of rare plant species along riparian zone. The first axes (horizontal axes) in figure 3 reflected elevation gradient, and the 14 rare plant species were classified to different quadrants commendably.

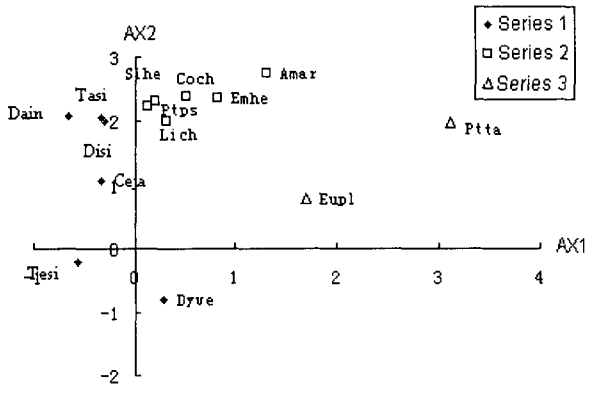

Fig. 3 DCA ordination of rare plant species along riparian zone

Discussion

It was confirmed that species biodiversity of plant community was maximum at the moderate elevation (He *et al.* 1997). Along with variation of elevation, temperature and precipitation were also varied. At the moderate elevation, temperature and precipitation were moderate generally, that offers a suitable habitat for rare plant species, and the intermediate disturbance hypothesis considered that there existed maximum species biodiversity under the moderate disturbance. Disturbance was considered as the direct reason causing spatial heterogeneity. In riparian zone, flood was confirmed as important disturbance by some studies (Nilsson *et al.* 1989; Tabacchi *et al.* 1996).

Harmonizing economical development and natural protection is the key of protecting biodiversity. Traditional biodiversity protection emphasized the single species protection and ignored habitat protection. Increasing studies indicated that it was impossible for a species to be protected effectively without considering it against the habitat background. Therefore, later protection biology theories come to focus on the combining protection of target species and their habitat. In Shennongjia Area, rare plant species distributing along the riparian zone is helpful to buffer the negative influence of local disturbance, and it is important and feasible to protect rare plant species under the scale of riparian ecosystem. Therefore, people should attach importance to the function of riparian zone on rare plant species protection..

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